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Japanese Kokai Patent Application No. Sho 63[1988]-9120

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KOKAI PATENT APPLICATION NO. SHO 63[1988]-9120

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## WAFER STAGE FOR DRY ETCHING

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[There are no amendments to this patent.]

Claims

1. A wafer stage for dry etching characterized by the fact that it has a substance that consumes the active radicals or ions in the plasma serving as the etching species for the resist on the substance being etched at least at the portion of the surface that is exposed during etching.

2. The wafer stage described in Claim 1 characterized by the fact that the aforementioned substance that consumes active radicals or ions is a substance with a different etching species from the substance being etched.

3. The wafer stage described in Claim 1 or 2 characterized by the fact that it is made of a material that contains the aforementioned substance that consumes active radicals or ions.

4. The wafer stage described in Claim 1 or 2 characterized by the fact that a separate member that includes the aforementioned substance that consumes active radicals or ions is arranged on its surface.

5. The wafer stage described in Claim 1 or 2 characterized by the fact that it has a coating layer on its surface that contains the aforementioned substance that consumes active radicals or ions.

6. The wafer stage described in any one of Claims 1 through 5 characterized by the fact that the aforementioned substance

that consumes active radicals or ions is selected from silicon (Si), carbon (C), or a compound of these.

#### Detailed explanation of the invention

##### Industrial application field

This invention pertains to a wafer stage used for dry etching devices for semiconductor production.

##### Prior art

Quartz and metal, e.g., aluminum (alumite surface) are used for the wafer stage in conventional dry process wafer etching devices, but with dry etching with a reactive plasma using wafer stages made with these materials, the etching selectivity for the photoresist on the article being etched, e.g., an  $\text{SiO}_2$  film on a silicon wafer surface and, on top of that, a poly Si or aluminum film, is mainly determined by the composition of the etching gas used. Also, with quartz stages, heat transmissivity is poor and it is difficult to cool the wafer on the stage. With metal, e.g., aluminum stages, there is contamination of the wafer surface.

##### Problems to be solved by the invention

The objectives of this invention are essentially to solve the problems in the conventional art stated above and to improve

resistance to dry etching of the photoresist, increase the etching selection ratio of the substance being etched to the resist, and to provide a wafer stage for dry etching that can be constructed by selecting a material with satisfactory heat transmissivity and that does not easily cause contamination.

#### Means for solving the problems

To accomplish the issues stated above, the wafer stage for dry etching based on this invention has a substance, for example, silicon (Si), carbon (C) and a compound of them, that consumes active radicals or ions in the plasma serving as an etching species for the resist on the substance being etched at least at the portion of the surface that is exposed during etching.

The aforementioned substance that consumes active radicals or ions should be a substance of a different etching species from the substance being etched.

In one embodiment of this invention, the stage is made of the aforementioned substance that consumes active radicals or ions, and in another embodiment, a separate member that contains the aforementioned substance that consumes active radicals or ions is arranged on its surface. In still another embodiment, this is formed as a coating layer.

#### Operation

The wafer stage for dry etching of this invention has a substance that consumes active radicals or ions that serve as the resist etching species, at least on the surface that is exposed

during etching. Thus the etching rate of the resist is reduced only by the portion consumed by this substance.

In this case, when a substance that does not consume the principal etching species of the substance being etched, or that does, but at a relatively low consumption rate, is used as the aforementioned substance, the etching selection ratio of the substance being etched to the resist will be further increased.

### Application examples

Figure 1 shows a cross section schematic diagram of a dry etching device that is a first application example of this invention. In the figure, (1) is a container that forms an etching reaction chamber, (2) is a gas feed section that supplies etching gas into the container, (3) is a gas feed pipe, (4) is a gas inlet section that doubles as a grounded upper electrode, (4a) are multiple feed openings provided in gas inlet section (4) through which gas flows into container (1), (5) is a discharge outlet for discharge gas from inside the container, and (6) is a suction pump that maintains a strong vacuum inside container (1) and at the same time discharges gas produced during etching. (7) is a stage electrode made of Al that functions both as an electrode for applying a high frequency to the wafer stage section and as a cooling section to release the heat of the wafer stage section; it is installed buried inside container bottom section (8) so that no portion will be exposed inside the container. Container bottom section (8) can be separated from container (1) and is made to move downward from the position in the figure with a raising/lowering mechanism, not shown. When

container bottom section (8) arrives at the position shown, the inside of container (1) is sealed, and when container bottom section (8) is lowered below this, wafers inside container (1) are replaced. Cooling device (9) is installed inside stage electrode (7).

A lateral cross section of cooling device (9) is shown in Figure 2. An insulating film is formed on the outside of outer wall (10) of cooling device (9); it is electrically separated from electrode (7). Partition (9a) is installed inside cooling device (9). This forms a flow path so that cooling water that enters from flow inlet (11b) will cool every part of cooling device (9) and exit through flow outlet (11a).

Referring to Figure 1, (11) is a cooling water circulation pipe, (12) is a cooling water circulation pump, and (13) is a heat dissipating section that discharges heat brought by the cooling water. (14) is a high frequency (RF) power source; here 13.56 MHz high frequency power is applied to stage electrode (7). Stage electrode (7) is constantly kept at a negative electrical potential. (15) is a wafer stage; it is installed in contact with stage electrode (7). It has essentially an electrical potential equal to that of stage electrode (7). (16) is a substrate mounted on wafer stage (15); here it is a ferrite substrate. An  $\text{SiO}_2$  film is formed on this substrate (16), and there is a resist pattern layer on this.

The operating method of this device will be explained. An etching gas, [in] 22\* a mixed gas of  $\text{CF}_4$ ,  $\text{C}_2\text{F}_6$  and He, at a ratio

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\* [Translator's note: "here" was probably misread and typed as "22."]

of  $\text{CF}_4$ : 10 sccm,  $\text{C}_2\text{F}_6$ : 8 sccm, and He: 80 sccm, is fed from gas feed section (2). The gas enters container (1) through multiple feed inlets (4a) of gas inlet section (4). The inside of container (1) is kept at nearly 100 Pa by suction pump (6) and a butterfly valve, which is not shown, between the pump and the container. Gas that enters container (1) goes to a plasma state because of the high frequency power between gas inlet section (4), that is an upper electrode, and wafer stage (15), which has an electrical potential equal to stage electrode (7). The  $\text{CF}_3^+$  ions generated at this time will flow toward ferrite substrate (16), which has an electrical potential equal to that of wafer stage (15), the cathode.

Figure 3 shows a top view of wafer stage (15). Wafer stage (15) is made in a tapered cylindrical shape, and its center section is indented so that a substrate will be mounted in this indented section. Mounting platform (17), which is made of monocrystalline silicon and 4 inches in diameter, is provided on the surface of this indented section. The other parts of wafer stage (15) are made of quartz. A part between ferrite substrate (16) and stage electrode (7) that doubles as a cooling section is formed of monocrystalline silicon, whose rate of heat transmission is sufficiently higher than quartz, so cooling efficiency will be better than when everything between is made of quartz.

$\text{CF}_3^+$  that collides with the  $\text{SiO}_2$  on ferrite substrate (16) where no pattern layer is formed produces a chemical reaction there, generating  $\text{SiF}_4$ , which is a gas even at normal temperatures, and the surface of the  $\text{SiO}_2$  film is removed.



Fluorine radicals (hereafter written  $F^{\cdot}$ ) generated in the plasma also react readily with monocrystalline silicon, like  $CF_3^+$ , so when  $F^{\cdot}$  arrives at the periphery of the stage section, most of it reacts with the monocrystalline silicon that composes mounting platform (17), generating  $SiF_4$ , that is, it is consumed by mounting platform (17). Thus,  $F^{\cdot}$  that etches the resist will be reduced by this amount, with the result that, with the device of this application example, resist etching by  $F^{\cdot}$  can be effectively reduced. In addition, since monocrystalline silicon contains no  $O^{\cdot}$  in its composition, there is no concern that, for example, the Si in mounting platform (17) will react with  $CF_3^+$  to generate  $O^{\cdot}$ . Since  $O^{\cdot}$  reacts easily with the resist to generate  $CO$ ,  $CO_2$ , and  $H_2O$ , the etching rate of the resist would be raised, but this problem will not occur with this application example.

#### Application Example 1 and Comparative Example 1

When a ferrite substrate chip with a photoresist (OFRR-800: trade name) pattern layer on an  $SiO_2$  sputtered film on its surface, about 5 mm x 20 mm in size, was actually etched with the device in Figure 1, the etching rate of the  $SiO_2$  was 1200 Å/min, the etching rate of the resist was 1100 Å/min, and the selection ratio, which is the ratio of the  $SiO_2$  etching rate to the resist etching rate, was about 1.1.

As a comparison, when the same type of chip was etched under the same conditions, except that wafer stage (15) was replaced with a stage of the same shape where mounting platform (17) was constructed only of quartz, the  $SiO_2$  etching rate was 1170 Å/min,

which did not essentially differ. The resist etching rate was 2270 Å/min, about 2 times the magnitude. From this result, it is clear that the selection ratio of the comparative example was 0.51, and that it was poorer than the application example of this application.

Some application examples of this application and comparative examples will be given below.

### Application Example 2

As shown in Figure 4, a P-doped poly Si film formed on an SiO<sub>2</sub> film on 4 inch silicon wafer (18) using the same device as in Figure 1 was dry etched as the substance being etched, except that a material where the surface of quartz stage (15) was coated with poly Si layer (15a) by an epitaxial growing device was used as the wafer stage.

Resist used: OFPR-800

Etching conditions: 200 W high frequency output  
10 Pa pressure

Etching gas: Cl<sub>2</sub> (22 sccm)  
CHCl<sub>3</sub> (8 sccm)

The etching species in this case is the chloride radical (Cl'), and poly Si layer (15a) consumes Cl'. The etching rate of the wafer's poly Si was 1895 Å/min, and the resist etching rate was 996 Å/min. This was a poly Si/resist [ratio] = 1.9.

### Comparative Example 2

The same wafer as in Application Example 2 was placed on a quartz stage with no coating layer and was dry etched under the same conditions.

In this case, the etching rate of the wafer's poly Si was 2360 Å/min, and the resist etching rate was 1638 Å/min. This was poly Si/resist ratio = 1.4.

As is clear from Application Example 2 and Comparative Example 2, with etching of poly Si in this case, the poly Si etching rate is simultaneously lowered because of the loading effect, but it is sufficiently increased as the selection ratio. In addition, it is effective for increasing the rate of heat transmission of the stage and for preventing contamination, and it will also increase the precision of fine pattern working by slowing the etching rate.

### Application Example 3

An aluminum (containing 1% Si) film formed on an SiO<sub>2</sub> film on a 4 inch wafer was dry etched using the same device as in Application Example 2.

Resist used:	HPR
Etching conditions:	100 W high frequency output 20 Pa pressure
Etching gas:	Cl <sub>2</sub> (20 sccm) BCl <sub>3</sub> (75 sccm) He (50 sccm) CHCl <sub>3</sub> (12 sccm)

The resist etching species is  $\text{Cl}^*$ , the same as in Application Example 2. The etching rate of the aluminum film in this case was 3330 Å/min, and the resist etching rate was 497 Å/min. This was an aluminum/resist [ratio] = 6.7.

#### Comparative Example 3

The same wafer as in Application Example 3 was dry etched under the same conditions using the same device as in Comparative Example 2.

The result: the etching rate of the aluminum film was 3330 Å/min, showing no change. On the other hand, the resist etching ratio was 951 Å/min. This was an aluminum/resist [ratio] = 3.5.

#### Application Example 4

As shown in Figure 5, carbon stage (15c), to which SiC film (15b) was applied, was used as the wafer stage, and a P-doped poly Si film formed on an  $\text{SiO}_2$  film on 5 inch silicon wafer (19) was dry etched.

Resist used: OFPR-800

Etching conditions: 100 W high frequency output  
4 Pa pressure

Etching gas:  $\text{Cl}_2$  (15 sccm)  
 $\text{CCl}_4$  (15 sccm)

The resist etching species in this case is  $\text{Cl}^*$ , and SiC film (15b) consumes  $\text{Cl}^*$ . The result: the etching rate of the poly Si

was 830 Å/min, and the resist etching rate was 271 Å/min. This was a poly Si/resist [ratio] = 3.1.

#### Comparative Example 4

Using a quartz stage as the wafer stage, the same wafer as in Application Example 4 was etched under the same conditions.

In this case, the etching rate of the poly Si was 1500 Å/min, and the resist etching rate was 818 Å/min. This was a poly Si/resist [ratio] = 1.8.

A variety of substances other than those given in the application examples above can be used for the aforementioned substances arranged on the surface of the wafer stage in this invention. For example, Si<sub>3</sub>N<sub>4</sub>, C, etc., selectively consume the radicals or ions in plasma that serve as etching species for the resist used. The substance should preferably have a different etching species than the substance being etched, and further, as long as it is a substance with excellent heat transmissivity and no danger of contamination, anything can be used. In addition, wafer stage (15) may be entirely composed of SiC, poly Si, etc.

#### Effects of the invention

As stated above, with this invention, the resist etching species is consumed by a specific substance on the surface of the wafer stage, so the etching selection ratio of the etched substance to the resist will be increased. In addition, since the surface of the wafer stage is composed of this type of

substance, it serves simultaneously to improve heat transmissivity and to prevent wafer contamination, and further, it is also useful as a means for regulating the etching rate.

Brief explanation of the figures

Figure 1 is a structural diagram showing a dry etching device that uses a wafer stage pertaining to an application example of this invention. Figure 2 is a top cross section of the cooling device in the same application example. Figure 3 is a top view of the wafer stage in the same application example. Figure 4 is a cross section showing a wafer stage pertaining to another application example. Figure 5 is a cross section showing a wafer stage pertaining to still another application example.

- |  |                                   |
|--|-----------------------------------|
| (1): cathode coupled system dry etching device |                                   |
| (4): gas inlet section                         | (5): vacuum gas discharge opening |
| (7): stage electrode                           | (9): cooling device               |
| (14): high frequency power source              | (15): wafer stage                 |
| (16): substrate                                | (17): mounting platform           |



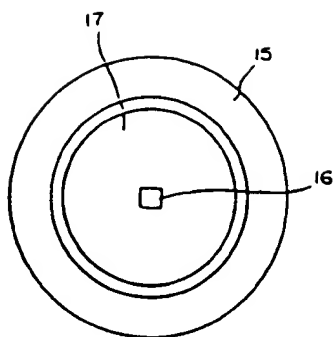


Figure 3

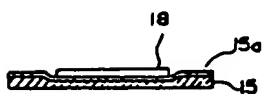


Figure 4



Figure 5